Empirical Modelling of the Mobile VoIP Demand

Hannu T. Verkasalo

Abstract— **This paper first discusses the future of mobile Internet voice and possible technical service evolution paths. Three main fundamental drivers of mobile VoIP (voice over IP) diffusion are identified theoretically. First, there should be need for mobile voice. Second, mobile broadband should penetrate to the mass market. Third, new packet data services including mobile VoIP clients should be developed and made available in the market. In the empirical part of the study the paper utilizes a new handset-based mobile service research platform with both questionnaire and usage data available from 695 Finnish smartphone users in 2006. The empirical study looks at three issues in the adoption of mobile VoIP. First, the adoption of alternative radio access technologies and mobile broadband is measured. Secondly, the adoption of mobile VoIP applications and services is studied. Finally, motivation and interest of subscribers towards mobile VoIP is addressed with questionnaire studies. All in all, there exists interest towards mobile VoIP, but the actual diffusion has not yet kicked off. Interests do not yet convert into actual use.**

***Index Terms*— mobile internet voice, handset-based market research, smartphones**

I. MOTIVATION

There will be three certain things driving the future of mobile voice market. First of all, there will be a need for a voice communications service. In other words, no substitute services could replace the voice service as we know it today. Consumers have an all-around need to communicate through voice also in the future. Voice is currently the most actively used mobile service even among early-adopter users (see the figure below; the data is based on the national Finnish smartphone service study in 2006). Second, voice services will gradually migrate to the mobile world. In other words, the fixed to mobile convergence will evolve further. Already today most voice calls in mature telecom markets take place in cellular networks instead of old PSTN networks. Third, mobile voice services will be deployed through packet switched technologies in the future. Circuit-switched technologies will be replaced eventually by Internet protocols. The movement to Internet technologies will take place in the mobile domain, too. It remains to be seen whether telecom operators or challenger players (e.g. Google, Microsoft, Skype) dominate the future mobile Internet.

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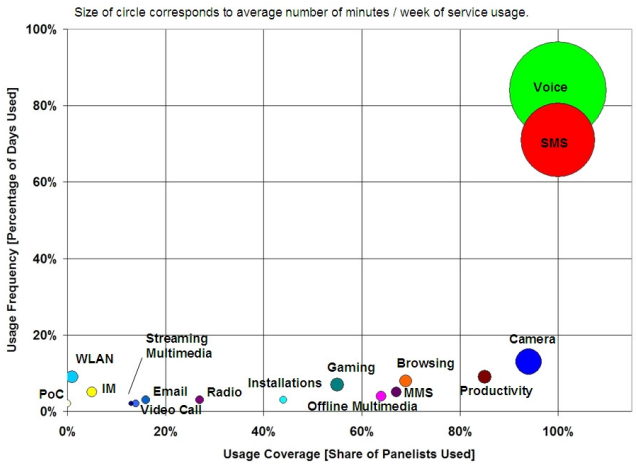

Figure 1 - Service penetration/frequency matrix (adapted from [1])

Given these major trends, there remain only two uncertain things. First, at which pace does the migration to mobile Internet voice service take place? Second, through which technologies and associated business models does the migration happen?

There is quite a lot of turbulence in the mobile VoIP scene right now. Legacy telecom operators have not said a word on mobile VoIP, mostly because they still consider the circuit-switched voice as their major cash cow. Nokia has announced its commitment to Gizmo mobile VoIP project [2], Fring attempts to combine both SIP and proprietary Internet technologies [3], Skype wants to deliver when the mobile integration of their service is mature enough and thus e.g. their Symbian client has been postponed [4], and Hutchison Three in the UK has bundled various Internet services into their device/service offering [18], including also Skype mobile VoIP connectivity. Lots of talk and hype thus exist around mobile VoIP services.

This paper sets out to discuss the background of the evolution towards mobile Internet services. Future mobile voice business scenarios are drawn. In addition, potential near future technical mobile VoIP deployments are described. In the main part of the paper empirical results on the emergence of mobile VoIP are presented. New handset-based mobile service research process [5] is utilized in the study. No other academic study has earlier combined questionnaire and usage-level empirical data together in analyzing mobile Internet services. This paper contributes particularly by providing a new angle of looking in a new service diffusion process both theoretically and empirically.

II. MOBILE VOICE SERVICE AND BUSINESS PROSPECTS

A. *Emergence of the Mobile Internet*

The number of mobile subscribers in the world has for long grown faster than the number of Internet users (see Figure 2). According to Nokia's estimations, the number of cellular subscriptions is likely to surpass three billion in 2008 [6]. The number of Internet connections is much lower, about 1 billion in 2005 [7], and the growth in the number of fixed broadband connections is much slower. In developing countries wireless infrastructure is built in locations where no wired telecom access exists, mainly because wireless infrastructure is cheaper and more flexible [8] [9]. It is no surprise that industry experts generally believe that in many developing countries people get their first experience with the Internet through a mobile handset. Given that packet-switched networks are more economical than circuit-switched networks and the Internet infrastructure has already matured for quite a while, it is possible that in the future all mobile services are delivered over Internet protocols.

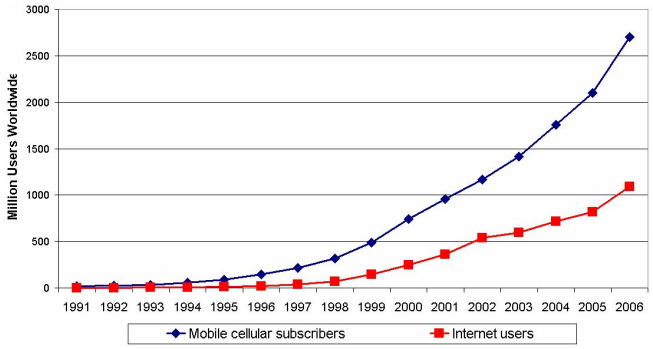

Figure 2 – Growth of cellular and Internet access (adapted from [10])

Nokia's top management says that Nokia has to revitalize itself for the future in order to keep up with industry evolution. In particular, Nokia as the world largest handset vendor aims to get closer to Internet businesses such as Google or Yahoo [11]. In services business higher operating profits could be maintained and the potential for new revenue sources is better. The P/E ratios for Nokia and Motorola are in February 2007 around 17 and 13, and for Google and Microsoft 48 and 25, respectively. That is, a software and Internet-oriented business focus is valued higher (given actual earnings) than consumer goods oriented business strategies. Services are increasingly catching the value created in the mobile industry from hardware, infrastructure and operator businesses. The convergence of the telecommunications industry with media industry further underlines that the potential for differentiation and market power (along with economic rents) will move from goods to services in the future of mobile industry.

Mobile service ecosystems are operator driven today. [19] In some markets such as Japan and the U.S. operators distribute terminals, charge and bill the customer, deploy services, and manage both the cellular access network and the network core. In general, mobile operators pursue vertically oriented strategies. Similarly handset vendors have focused on developing and manufacturing terminals as cheaply as possible, without significantly taking part in the mobile services business. Few specialized mobile service or content houses exist, with the exception of Japan and NTT DoCoMo's I-mode. Legacy cellular services mostly include voice and simple messaging services, such as SMS. These services still represent most of cell phone usage [12].

The world of Internet has faced a much different industry evolution. Instead of network centricity (cellular operators in the mobile industry have still retained much of the control and intelligence in the network), the Internet has leveraged network edge based innovation and open standardized interfaces. The network itself embraces the value, not individual nodes. The all-IP movement is taking place [13], pushing the Internet towards the mobile world, too. Whereas cellular services ecosystems have been largely managed by cellular operators in a vertically oriented manner, the Internet model is based on horizontal business models. That is, separate access network operators exist, and the services are provided independently of access by specialized service providers. Internet services are mostly free or flat rate oriented, and the business logic is based on e.g. advertising revenues. Transaction costs are basically zero, and network externalities in e.g. instant messaging networks are valued high. The economics of information societies, pushed by the Internet evolution, are much different from the economics of many other industries [14]. Reshaped Internet business logic therefore holds lots of potential to shake dominant business models of the mobile industry, too.

B. *Mobile Voice Business*

Lindqvist [15] takes a business strategic perspective on the evolution of the mobile voice market. The foundation of the research is in scenario analysis, see e.g. [17]. He identifies three major trends taking place:

- There will be a non-decreasing demand for mobile voice services
- Fixed-to-mobile substitution will evolve further
- Packet-switched connectivity and Internet service platforms will emerge

Based on the above mentioned trends, Lindqvist developed a scenario model of the future mobile voice market. The final scenarios are contingent on two factors (see below): market structure and access mode.

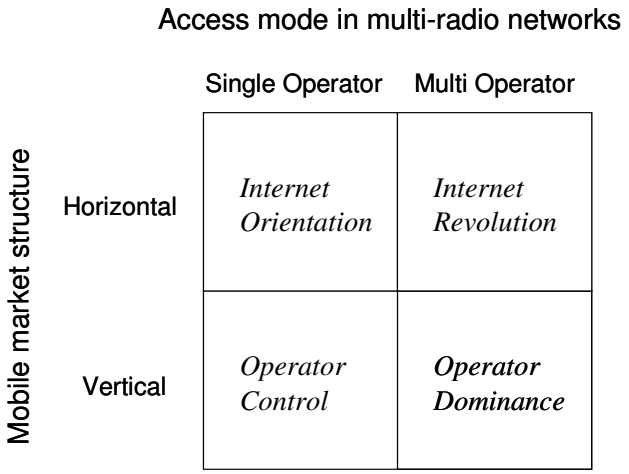

Figure 3 – Future scenarios of mobile voice market

"Operator control" and "Internet revolution" are the two extreme scenarios. In the first one the market is still operator-driven, and operators have vertically oriented business models in the mobile voice business. Operators deploy Internet technologies in providing mobile voice services, but truly open Internet kind of horizontal competition has not taken place. Operator have been able to utilize their radio access networks, levers in handset bundling, and large customer base in winning the game for mobile voice.

In Internet revolution open network-edge based innovation and new challenging players invade to the mobile voice market. Incumbent mobile operators have to stick to bit-pipe operator strategies, as new players will dominate the mobile services industry. Mobile voice will be provided by new actors, such as Skype or Google. Legacy telecom networks (current 3G and 2.5G infrastructure) are used only as one possible radio access or bit pipe to the Internet.

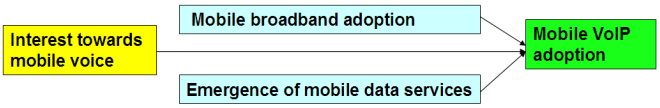

Figure 4 – Drivers of mobile VoIP adoption

The actual adoption of mobile VoIP depends on many things, as depicted in the theoretical model of the figure above. First of all, there should be the demand for mobile voice. This is probably the most certain thing of all. In addition, mobile broadband penetration should go up. Mobile VoIP requires mobile packet access connectivity. Correct pricing, marketing and technical implementation of mobile packet access is inevitable. In addition, diffusion of mobile broadband equipped handsets is needed for mobile VoIP to fly. Diffusion of 3G capable handsets, devices with WiFi connectivity embedded, and hotspot networks, for example, are required for sufficient mobile broadband diffusion. In addition to mere packet data access diffusion, also suitable applications and services are required. This includes the development and introduction of mobile VoIP clients and software. The deployment of SIP (for standardized SIP mobile VoIP) or support for third party applications in smartphones (for applications such as mobile Skype) should be looked upon. All of these three fundamentals (interest, mobile broadband diffusion, emergence of mobile data applications and VoIP clients) for the mobile VoIP adoption can be measured with the new handset-based mobile service platform [5].

C. *Mobile Internet Voice Services*

Mobile VoIP can be deployed in many ways. There are three major alternatives:

1. **Proprietary clients.** Skype is a good example of a purely Internet-originated VoIP service, which utilizes proprietary technology. In other words, Skype has not revealed the technical framework of its service, and therefore the development can take place only inside Skype. Some new applications such as Fring, however, can utilize Skype networks with Skype gateways. However, the control of the service is at Skype.

2. **Operator-controlled Internet voice**. Incumbent cellular operators can migrate their circuit-switched voice to packet-switched networks. This can be done with the help of e.g. the open SIP protocol, UMA architecture or more closed IMS platforms.

3. **Challenger virtual VoIP services.** Light-weight virtual operators might emerge by deploying SIP technology to provide mobile voice services. Incumbent operators are, however, still needed in providing the bit-pipe for mobile voice. Some companies such as TruePhone might find a slot in the mobile voice market by becoming a virtual mobile VoIP operator. Nokia is also experimenting in this area with its Gizmo partnership.

Technically mobile VoIP is already possible. However, in developing mobile VoIP further many issues are still to be resolved. One of them is the controlling/charging of mobile VoIP, particularly if truly Internet-based VoIP services are to emerge in the market. Another key issue is the radio network technology, including e.g. quality of service parameters such as end-to-end delays and handover management. With regards to challenger mobile VoIP services (e.g. virtual operators with SIP and proprietary technologies like Skype) the switching gateways and associated call termination charging of Internet to PSTN/mobile networks are both a regulatory and technical challenge.

III. Empirical Analysis

A. *Research Methods and Data*

A pioneering mobile end-user research platform was utilized in acquiring data for this research paper. The new

mobile end-user research platform is based on a developed Symbian/S60 smartphone client that observes all kinds of usage actions taking place in the handset. Usage-levels stamps on any application, network or user interface level action is logged with accurate context-specific information (e.g. time). This data is sent to centralized servers every night for analysis purposes. Research is conducted in panels lasting typically 2-3 months, and a typical panel includes hundreds of interested customers which in the panel become panelists. All panelists participating in these study panels sign a contract and they are aware of the research process. Usage data is complemented with various WWW-based questionnaires through which to acquire data on issues that are not usage-related (e.g. motivations and attitudes). Though the accuracy and scope of acquired data is a clear contribution in the world of end-user research, the challenges include e.g. biased end-user domain (early-adopter users) and sample size (being still in the range of 400-1000 panelists). For more information on the research method, see [5].

The dataset of this paper includes 695 active panelists from a Finnish smartphone study arranged in fall 2006. The panelists were predominantly early-adopter Nokia smartphone users. 78% of active panelists were male, and 18% were female. 4% of active panelists did not reveal their gender. Most panelists (66%) were 20-39 years old. 86% of panelists paid the bill themselves (thus this is a consumer panel). Most panelists were working/studying fulltime. These early-adopter users are now used as a sample of mobile subscribers for empirical measurement of mobile VoIP diffusion in high-end customer segments of the mobile industry. More specific results on the study can be found from [12].

B. Empirical Observations

A typical Finnish panelist allocates 33% of her usage time on voice calls (currently almost entirely circuit-switched voice), and 24% on messaging. A typical panelist spends about 10 minutes / day on voice calls and 7 minutes on messaging, but there are clearly more active users, too. Top 25% of voice users, for example, spend an average of 15-30 minutes / day on voice. Therefore the demand for mobile voice is still significant, though many new mobile services have appeared in the market.

On an aggregate level roughly half of all observed packet data is already over WCDMA bearer (46%). EDGE (21%) and GPRS (18%) thus are already behind WCDMA volumes in Finland, even when summing them together to form the 2G-2.5G data volume (39%). The most interesting observation is the share of WLAN traffic (15%), though only a small share of panelists (1%) have used WLAN bearer. Among WLAN device owners the share of WLAN traffic is even more (63%). This is even though only 38% of WLAN handset owners have actually generated packet data with WLAN (and 70% of WLAN device owners having generated any packet data in general). This indicates that the more capable the bearer, the easier it is to generate huge chunks of packet data. Higher bandwidth bearers did not help earlier, as phones did not have rendering power to show web sites quickly enough (browsing is still the key service in generating data). Now it is the opposite, the smartphone rendering is not the bottleneck that much any more, but instead the GPRS/EDGE bearers which just cannot feed traffic quickly enough. WLAN bearers (and WCDMA) support fluent use of the Internet. All in all, 84% of all data traffic in the panel was of TCP/IP type, and 16% was UDP or something else.

Data plans have a significant effect on packet data generation. A typical subscriber with usage-based data plan generated only 307 KB / month, whereas a subscriber with block-priced data plan generated 3 533 KB / month and flat-rate subscriber 2 954 KB / month. Data traffic amounts are reported also in arithmetic means in table below. When comparing the table below to similar tables related to voice and SMS usage, it can be noted that data service usage is probably more price-elastic than more mature service usage. More accurate studies indicate that in addition to data plan the type of handset significantly affects usage. The impact of 3G capability among block-priced data plan subscribers, for example, was an 86% increase (in median usage intensity). Those customers who have a proper data plan (not usage-based) are more likely to explore data services.

TABLE 1 - MEAN PACKET DATA TRAFFIC [MB/MONTH/USER]

Device	Usage-based	Block-priced	Flat-rate	Total
2.5G Phone	1.21	3.68	0.75	1.46
3G Phone	8.34	6.73	42.08	8.63
Total	5.64	6.39	39.02	6.72

5% of all panelists generate at least 20 MB of packet data traffic / month. About 20% of panelists generate at least 5 MB / month. In cumulative terms 10% of panelists generate about 80% of all packet data observed in the panel study, and 20% of panelists generate about 90% of all packet data observed. 8%, 46% and 48% of subscribers with usage-based, block-priced and flat-rate data plans generate at least 4 MB / month of data traffic. Most people (68%) considered their mobile Internet connection expensive, whereas only 23% said the price is reasonable.

No actual usage of VoIP clients can yet been observed in the data. Nobody tried SIP-based mobile VoIP. This is despite the fact that as many as 7% of the subscribers owned a smartphone supporting SIP. According to the questionnaire results the technical configuration of new smartphones to support e.g. email or VoIP is very difficult [12]. In addition to the difficulties of configuring SIP settings, existing SIP based mobile VoIP services received little attention in Finland in 2006 and no-one of the major operators particularly promoted SIP-based services. These reasons probably explain why no use of the SIP protocol among the studied set of mobile devices was observed.

Only 0.5% of panelists used 3rd party mobile VoIP clients (e.g. Fring, Skype). 13% tried instant messaging clients, which to some extent can be considered as a preliminary indication of increasing Internet-based mobile communications. Although the numbers are not that high, the comparison to inexistent use of SIP suggests that if Internet based mobile communications services flew, they would

probably fly easier through clients that support fluent capitalization on the value already embedded in existing Internet services. In most cases this means that a dedicated client (like MSN Live Messenger or Fring) is deployed on the smartphone software platform (Symbian or Windows Mobile) and the client directly supports (proprietary) Internet communication protocols (e.g. MSN, Skype, Yahoo, GoogleTalk) without any operator-driven standards (like SIP). The spill-over effects of the fixed Internet [16] might therefore be quite significant in the mobile domain.

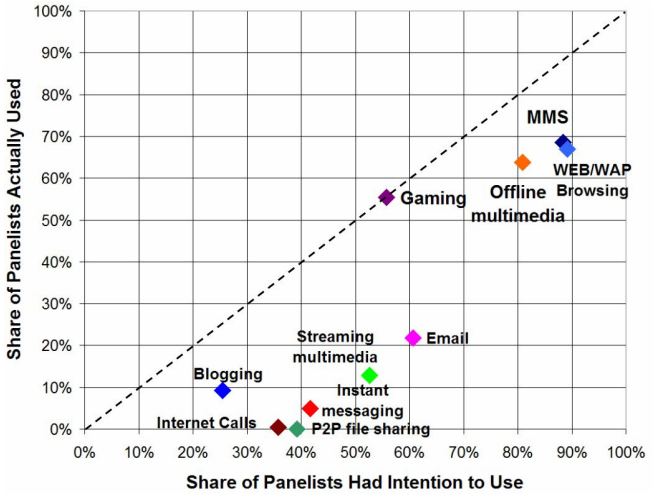

Figure 5 – Interest towards and usage of mobile services

On an aggregate level, as can be seen from the figure above, both VoIP and instant messaging services experienced little usage. This is even though a very high-end of the mobile subscriber domain (i.e. early-adopters) was studied.

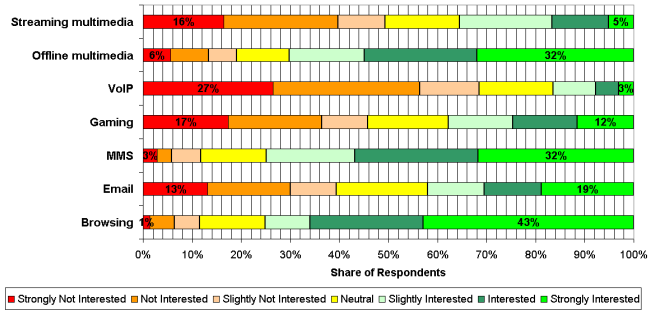

Figure 6 – Potential of emerging mobile services in 2006

Despite little actual VoIP usage, already 36% of all panelists indicated in 2006 that they do not have negative attitude towards mobile VoIP (in other words, they have either neutral or positive attitude towards mobile VoIP). However, only 3% of respondents were strongly looking forward to trying Internet calls in the near future. This is the lowest figure of all when comparing the seven included mobile services against each other. The figure above presents the results of the questionnaire study in 2006 that asked whether panelists are interested in trying the particular services during the panel study.

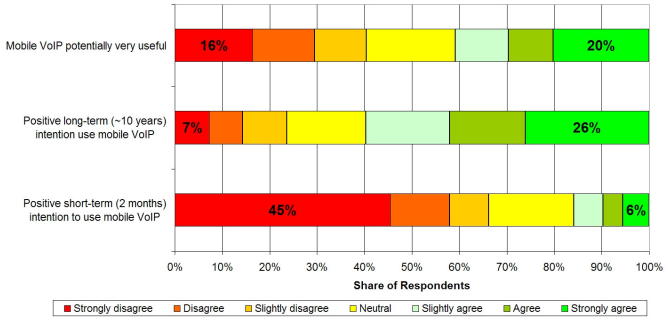

Figure 7 – Statements on mobile VoIP in 2007

Some of the new questionnaire results (from the study of 2007) are reported above. The question regarding short-term intention revealed that the short-term neutral/positive intention (34%) has stayed on the same level as above with the results of 2006 (36%). There were also new questions asked with regards to mobile VoIP. As many as 76% of panelists have either neutral or positive long-term intention to use mobile VoIP. In other words, though only a small share of panelists claim that they will use mobile VoIP in the near future, most panelists already think that in the time-frame of 10 years they will adopt mobile VoIP in the form or another. Regarding the usefulness (value-added) of mobile VoIP people were divided into two equally large groups.

All in all, there is little mobile VoIP usage. There is some interest towards mobile VoIP among early-adopter users based on the questionnaire study, but this interest does not yet convert into actual use. However, the prospects of mobile VoIP do not look that promising as the prospects of some other emerging mobile services (like the strong diffusion of mobile Internet browsing or MMS messaging; [12]).

IV. Conclusions

This paper first discussed the future of mobile Internet voice and possible technical service alternatives. The mobile Internet business scenario was contrasted with the classical vertically oriented cellular business infrastructure. The future of mobile voice will be in Internet technologies, but the pace at which the diffusion proceeds and the dominant business model of mobile voice are still uncertain. The three main technical mobile VoIP alternatives are operator-originated mobile VoIP (mobile Internet voice is provided by legacy telecom operators through e.g. IMS), virtual operator originated VoIP (challenger operators utilizing e.g. SIP) and proprietary Internet services (e.g. Skype).

The paper finds that mobile broadband diffusion is very promising in Finland. Adoption of WiFi and WCDMA mobile broadband has pushed data service usage. However, no actual use of VoIP clients was yet been observed. Nobody tried SIP-based mobile VoIP. Only 0.5% of panelists used 3rd party mobile VoIP clients (e.g. Fring, Skype). Despite the poor results of mobile VoIP diffusion, already 34%-36% of all panelists indicated that they are positively looking forward to trying Internet calls in the near future with mobile devices, and 76% are likely to use mobile VoIP within 10 years. This means that there is demand for mobile VoIP. Most people

(68%) considered their mobile Internet connection expensive, whereas only 23% said the price is reasonable. All in all, there exists some interest towards mobile VoIP, but the actual diffusion has not yet kicked off.

Future research should be geared in

- understanding the business landscape for mobile VoIP
- conducting longitudinal end-user analysis to measure mobile VoIP diffusion
- modeling the bottlenecks and drivers of mobile VoIP service adoption

This paper provided the first empirical study setting to analyze the actual diffusion of mobile VoIP. Though the data was acquired from early-adopter users, the results provide indicative results on mobile VoIP diffusion. Little usage exists, though some interest exists. In comparison to other mobile services, however, people are quite skeptic on mobile VoIP.

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